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STUDIES ON WESTERN AUSTRALIAN PERMIAN BRACHIOPODS
5. THE FAMILY DICTYOCLOSTIDAE STEHLI 1954

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Abstract: Dictyoclostidae from the Permian sequences of Western and northwestern Australia are revised and described. The new genus *Callytharrella* is diagnosed and the following species described: *Callytharrella callytharrensis* (Prendergast), *Costiferina wadei* (Prendergast) and *Costiferina thomasi* sp. nov.

This paper continues the series of studies on Western Australian Permian brachiopods (Archbold 1984). Representatives of the Dictyoclostidae occur at selected stratigraphical horizons within the Permian sequences of the Perth, Carnarvon, Canning and Bonaparte Gulf Basins. The stratigraphy of these basins is documented in references referred to in Archbold (1981, p. 109) and the basis for age assignment of species is also outlined in Archbold (1981). Terminology is standard as in previous studies. Specimens are figured at natural scale in this study whereas previously (Prendergast 1943, Coleman 1957) important type and other specimens have been figured at reduced scales making comparisons with the other species and genera more difficult.

COLLECTIONS

All figured and measured specimens are housed in the following institutions as indicated by the prefix to the registered numbers. CPC—Commonwealth Palaeontological Collections of the Bureau of Mineral Resources, Geology and Geophysics, Canberra, A.C.T. GSWA—Geological Survey of Western Australia, Perth, Western Australia. MUGD—Department of Geology, University of Melbourne, Parkville, Victoria. UWA—Department of Geology, University of Western Australia, Nedlands, Western Australia. AMF—Australian Museum, Sydney, N.S.W.

SYSTEMATIC PALAEONTOLOGY

Order Productida Sarycheva & Sokolskaya 1959

Superfamily Productacea Gray 1840

Family Dictyoclostidae Stehli 1954

Genus **Callytharrella** gen. nov.

Type Species: *Dictyoclostus callytharrensis* Prendergast 1943.

Diagnosis: Large, transverse dictyoclostids with large ears and ventral valve with broad, convex visceral disc and strongly curved, sulcate trail at maturity. No dorsal spines. Ventral spines scattered over visceral disc (associated with reticulate ornament), relatively few on long trail and small cluster on prominent ears. Costae prominent over anterior of ears at maturity and converge in sulcus. Dorsal valve strongly geniculate.

Discussion: The examination of a large collection of specimens has permitted a substantial revision of Prendergast's *Dictyoclostus callytharrensis*, as discussed below, which in turn has revealed the distinctive features of *Callytharrella* gen. nov. *Stereochia* Grant (1976) to which Prendergast's species was referred by Grant, and subsequently by Archbold (1982b), is distinguished from the new genus by means of its smaller quadrate ears with few spines, smaller size and less prominent trail. Mature *Callytharrella* gen. nov. is transverse whereas *Stereochia* is more quadrate in outline and the costae of *Callytharrella* gen. nov. are finer than those of *Stereochia*. Costae are distinct on the ears of gerontic *Callytharrella* gen. nov. but not on the ears of *Stereochia* where the costae are normally absent.

Other dictyoclostid genera are readily differentiated from *Callytharrella* gen. nov. *Costiferina* Muir-Wood and Cooper (1960) possesses a distinctive dorsal marginal ridge and its dorsal valve has a less extensive reticulate zone. Costae of *Callytharrella* gen. nov. are much finer than those of *Costiferina*. *Squamaria* Muir-Wood and Cooper (1960) is most readily distinguished from *Callytharrella* gen. nov. by the cluster of spines in 3 or 4 rows on the ventral ears as well as the cluster of spines on the dorsal ears. *Antiquatonia* Miloradovich (1945) is somewhat similar externally to *Callytharrella* gen. nov. however, differs in possessing rare dorsal spines and a distinctive curved row of spines on the ventral flanks, often developed on a distinct rounded ridge. Costae of *Antiquatonia* are finer than those of *Callytharrella* gen. nov. *Reticulatia* Muir-Wood and Cooper (1960) resembles *Callytharrella* gen. nov. externally but *Reticulatia* possesses a weakly developed sulcus and few, fine ventral spines. *Reticulatia* also possesses a distinct dorsal marginal ridge and distinctive overlapping growth lamellae on the anterior of the ventral valve. Costae are poorly developed or absent on the ears of *Reticulatia*.

Callytharrella callytharrensis (Prendergast, 1943)
Figs 1A-T, 2A-F, 3A-H

1902 *Productus semireticulatus*: Etheridge. In, Maitland, A.G.; *Ann. Prog. Rep. Geol. Surv. W. Aust.*, 1901: 12.

1903 *Productus semireticulatus*: Maitland. In, Fraser, M.A.C. (ed.); *Notes on the Natural History etc. of Western Australia*, p. iv.
1903 *Productus semireticulatus*: Etheridge. *Bull. geol. Surv. W. Aust.*, 10: 18, pl. 2, figs 3-5.
1904 *Productus semireticulatus*: Maitland. *Rep. A'asian Assoc. Advmt Sci.*, 10: 619.
1907 *Productus semireticulatus*: Etheridge. *Bull. geol. Surv. W. Aust.*, 27: 29.
1910 *Productus semireticulatus*: Gläuert. *Bull. geol. Surv. W. Aust.*, 36: 87.
1912 *Productus semireticulatus*: Maitland. *Jour. Nat. Hist. Sci. Soc. W. Aust.*, 4: 23, 26.
1919 *Productus semireticulatus*: Maitland. *Mem. geol. Surv. W. Aust.*, 1: 34, 38.
1924 *Productus semireticulatus*: Chapman. p. 36.
1931 *Productus semireticulatus*: Hosking. *J. Roy. Soc. W. Aust.*, 27: 8, 22.
1936 *Productus semireticulatus*: Chapman. In. Raggatt, H. G., *J. Proc. Roy. Soc. N.S.W.*, 70: 128.
1937 *Productus semireticulatus*: Clarke. *Rep. Aust. N.Z. Assoc. Advmt Sci.*, 24: 429.
1937 *Productus semireticulatus*: Raggatt and Fletcher. *Rec. Aust. Mus.*, 20(2): 168, 169, 174.
1937 *Productus* cf. *spiralis*: Raggatt and Fletcher. *Rec. Aust. Mus.*, 20(2): 169, 174.
1937 *Productus* cf. *indicus*: Raggatt and Fletcher. *Rec. Aust. Mus.*, 20(2): 169, 174.
1943 *Dictyoclostus callytharrensis* Prendergast, p. 13, pl. 1, figs 1-7; pl. 2, fig. 1.
1943 *Dictyoclostus spiralis*: Prendergast, p. 18, pl. 2, figs 8-9.
1952 *Dictyoclostus callytharrensis* Prendergast: Teichert. *Symposium sur les Series de Gondwana; 19th Int. Geol. Cong. Alger*, pp. 117, 121, 122.
1957 *Dictyoclostus* (*?Antiquatonia*) *callytharrensis* Prendergast; Coleman, p. 54, pl. 6, figs 3-14.
1957 *Dictyoclostus* (*?Antiquatonia*) *magnus* Coleman, p. 57, pl. 7, figs 1-6.
1967 *Dictyoclostus callytharrensis* Prendergast; Condon, p. 70.
1967 *Dictyoclostus magnus* Coleman; Condon, p. 70.
1967 *Dictyoclostus* Condon, p. 90.
1969 *Costiferina callytharrensis* (Pendergast); Thomas. In, Gondwana Stratigraphy (I.U.G.S. Symp.), p. 220.
1971 *Reticulatia callytharrensis* (Prendergast); Waterhouse. *Proc. Pap. 2nd Gondwana Symp.*, p. 391.
1971 *?Reticulatia magnus* (Coleman); Waterhouse. *Proc. Pap. 2nd Gondwana Symp.*, p. 391.
1975 *Dictyoclostus callytharrensis* Prendergast; Playford *et al.*, pp. 233, 281, 282.
1976 *Costiferina callytharrensis* (Prendergast); Playford *et al.*, p. 95.
1976 *Costiferina magnus* (Coleman); Playford *et al.*, p. 95.

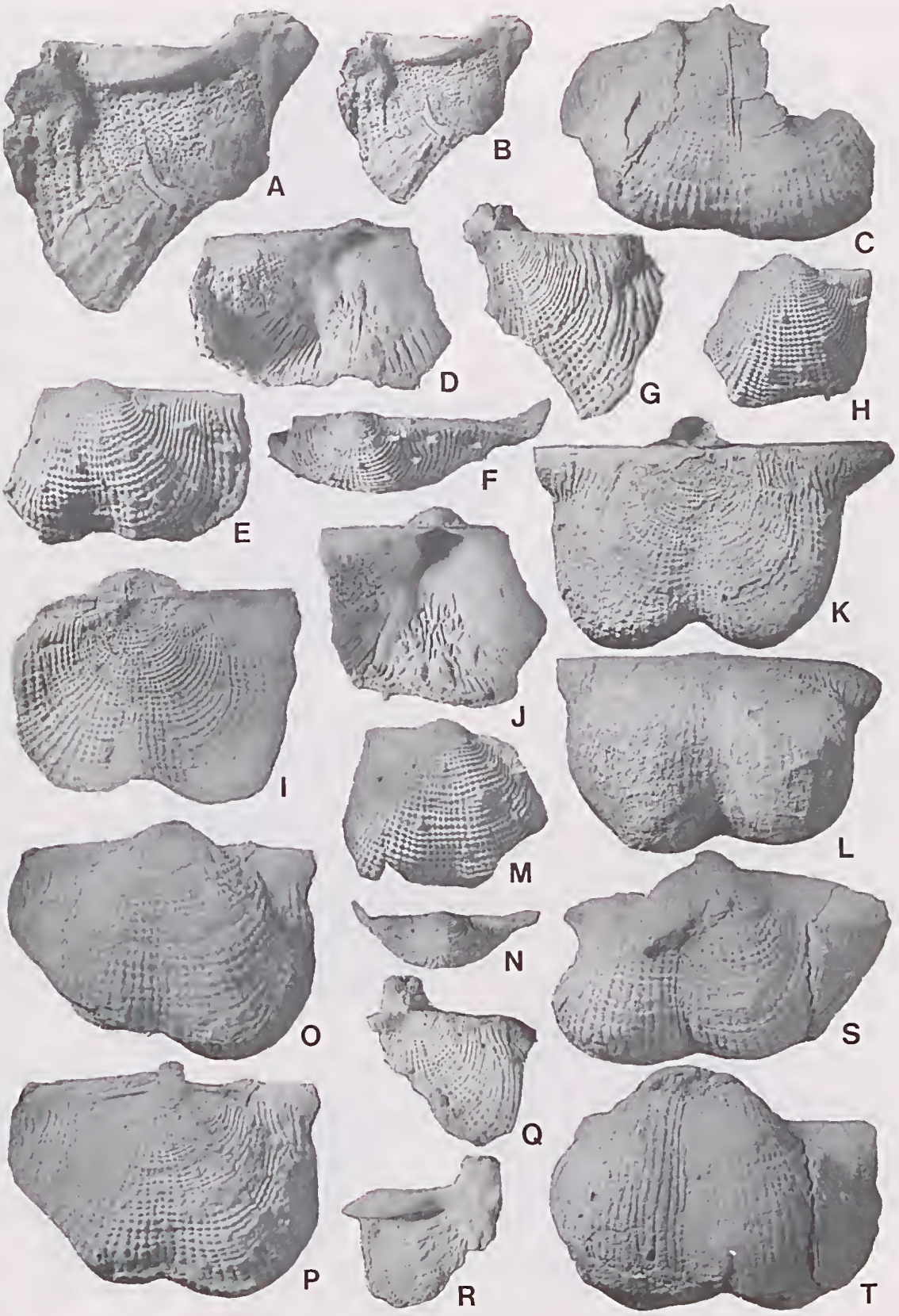
LECTOTYPE: GSWA 1/4967b figured by Prendergast (1943, pl. 1, fig. 3) and Coleman (1957, pl. 6, figs 9, 10); 0.8 km west of Callytharra Springs, Wooramel River District, Callytharra Formation, chosen by Coleman (1957, p. 54).

MATERIAL, LOCALITIES AND AGE: Specimens as figured and measured in addition to abundant, usually crushed and incomplete material from the Callytharra Formation in the GSWA and MUGD collections include: AMF 36514 and AMF 36515, 2 ventral valves from Wyndham Gap, Callytharra Formation, Carnarvon Basin. MUGD F 6006-6007, 2 incomplete ventral valves from locality P 494; F 6008, an incomplete ventral valve from locality P 481; F 6013-6114, an incomplete dorsal valve and a ventral valve from locality P 498, all G. A. Thomas localities, type section of Callytharra Formation, Callytharra Springs; 34 m, 29 m, 24 m and 34-38 m from base of formation respectively. MUGD F 6018-6019, a ventral valve and an incomplete shell from G. A. Thomas locality R 654, in ridge on north side of Baragooda Pool, Arthur River, Bidgemia Station, 30.15 m above base of measured section of Callytharra Formation. MUGD F 6020-6021, a dorsal valve external mould and an incomplete dorsal valve from G. A. Thomas locality S665, 8.4 km bearing 226° from Coondoo Outcamp, Bidgemia Station near base of Callytharra Formation. CPC 19910, a ventral valve BMR locality GW 134, 25°52'S, 115°31'E, type section of Callytharra Formation, Callytharra Springs, 27-32 m above base of formation. All Sterlitamakian (Late Sakmarian).

GSWA F 270, a conjoined shell and GSWA F 6380, a ventral valve both from Fossil Cliff, Irwin River District, type section of Fossil Cliff Member, Perth Basin. Sterlitamakian (Late Sakmarian).

CPC 19911, a conjoined shell from BMR locality WO3, type section of the Jimba Jimba Calcarenite (25°02'75"S, 114°58'5"E), Jimba Jimba Station, 15 km west of Jimba Jimba Homestead (Condon 1967, p. 89) Carnarvon Basin. Aktastinian (Early Artinskian).

Fig. 1—A-T, *Callytharrella callytharrensis* (Prendergast). A-N, Q-R, from Callytharra Formation, Carnarvon Basin; O-P, S-T, from Fossil Cliff Member, Perth Basin. A,B,G, MUGD F6012, incomplete dorsal valve in ventral views, ×2 and ×1.1 and dorsal view, ×1.1. C, MUGD F6013, incomplete dorsal valve in ventral view, ×1. D-F, MUGD F6008, incomplete ventral valve in dorsal, ventral and posterior views, ×1.3, ×1.3 and ×1.6 respectively. H, J, MUGD F6006, incomplete ventral valve in ventral and dorsal views, ×1.3 and ×2 respectively. I, MUGD F6019, incomplete shell in dorsal view, ×1. K,L, MUGD F6020, dorsal valve external mould in ventral and anterior views, ×1. M,N, MUGD F6007, incomplete ventral valve in ventral and posterior views ×1. O-P, GSWA F270, shell in ventral view and corresponding dorsal valve, ×1. Q-R, MUGD F6011, incomplete dorsal valve in dorsal and ventral views, ×2. S-T, GSWA F6380, ventral valve in posterior and ventral views, ×1.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MEASUREMENTS (in mm): e = estimate

Specimen	Hinge width	Mid-length width	Ventral height	Dorsal height	Thickness	Formation
AMF 36514	86	80	51	—	43e	Callytharra
AMF 36515	61+	51e	—	—	—	Callytharra
MUGD 6010	58e	50e	45	—	30e	Callytharra
MUGD 6018	74	58e	49e	—	—	Callytharra
CPC 19911	51+	51	52	41	40	Jimba Jimba
GSWA F 270	40+	45	35	32	—	Fossil Cliff
GSWA F 6380	48e	48e	41e	—	—	Fossil Cliff

DIAGNOSIS: Huge for genus. Ornamentation fine for size of species; ears distinct. Costae grouped into weak fasciculae on weak folds of trail. Ventral sulcus distinct, dorsal fold developed anteriorly.

DESCRIPTION: Huge for genus; outline transverse, widest at hinge at maturity; profile fairly evenly curved, gentle geniculation at anterior of visceral disc. Ears inflated, distinctly alate in gerontic individuals, tips of ears squared presenting quadrate outline. Anterior margin emarginate producing broad, deep sulcus. Ventral umbo short, slightly inflated; visceral disc strongly reticulate. Rugae initially stronger than costae (for first cm of growth) then costae of equal strength; costae continue forward of rugae for anterior two-thirds of fully mature shells; costae strong, fine (0.5 to 1.5 mm wide on trail), crests rounded, occasionally bifurcating on the anterior side of spine, superimposed on weak raised folds (or plications) of shell, group of three or four fine costae arise on each plication, this pattern imparting weak fasciculate appearance to costae on trail; costae persist to anterior of trail. Costae converge in sulcus, at least one pair being lost. Sulcus arises about midpoint of visceral disc, indistinct initially. Spines prominent, in row parallel to hinge with minute spines near umbo and up to seven coarse spines on ears of gerontic individuals, including about four in row near hinge, widely spaced row near depression demareating ears from rest of ventral valve each progressively coarser with the final two spines of row functional, finer spines scattered over visceral disc usually abraided off mature specimens, coarser spines scattered at random on trail—about 10 functional; diameter of anterior trail spines 1.5 to 2 mm. Dorsal valve slighly concave on visceral region with low median fold; strongly geniculated to form trail; body chamber large; reticulate ornament extends over entire visceral disc; trail costate as on ventral valve; no spines; low pits scattered over valve, broadly corresponding to ventral spine positions. Hinge edge sharp, bearing against low, distinct ventral ginglymus.

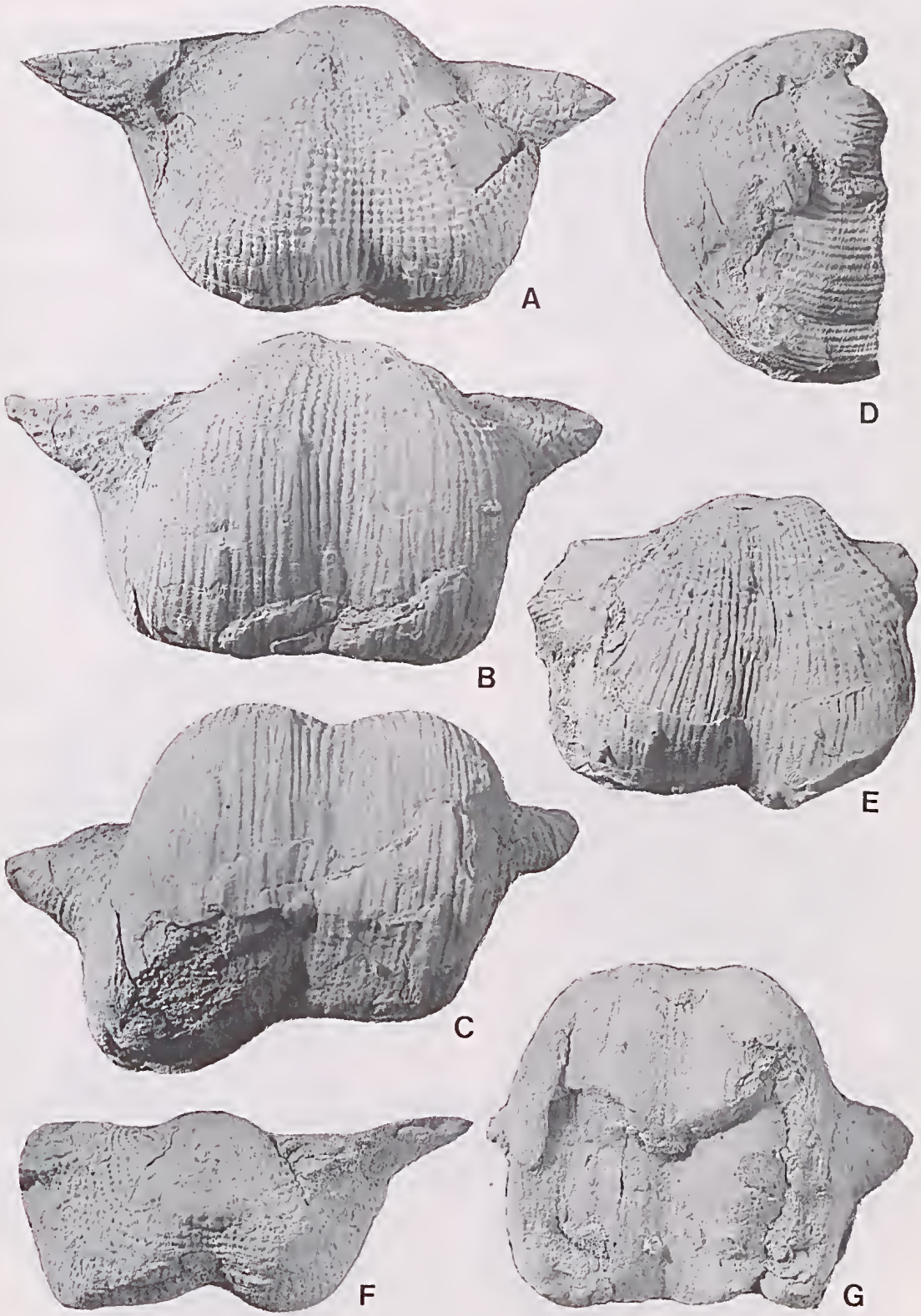
Ventral interior deep, pitted visceral region (excluding muscle scars); diducator scars large, longitudinally striate; adductor scars dendritic, narrow, anteriorly on slightly raised median platform; exterior ornament weakly reflected on inner surface of valve except where thickened or searred. Ginglymus possesses small V-shaped notch under umbo in juvenile shells, subsequently sealed by shell thickening. Dorsal interior with low marginal ridge across ears, absent anteriorly; cardinal process short, trilobed, with small, sharp lophidium not continuous with median myophore; median lobe reduced in thickened specimens; process supported by lateral ridges and median septum which continues forward between muscle scars becoming thinner and sharper, terminating about two-thirds distance to geniculation. Adductor scars in two pairs, median pair extending forward further than lateral pair; brachial ridges weak to distinct, tear-shaped anteriorly.

DISCUSSION: *Callytharrella callytharrensis*, although a common species, is invariably represented by incomplete, crushed specimens normally with the ears damaged and the trail broken and crushed or completely removed. Specimens examined for the present review permit a uniting of the two species *Dictyoclostus callytharrensis* Prendergast and *Dictyoclostus* (?*Antiquatonia*) *magnus* Coleman. The holotype of Coleman's species is a gerontic representative of Prendergast's species and the differences between the two species, as discussed by Coleman (1957, p. 58), can be explained by ontogenetic variation. The older the individual, the smaller the proportion of the shell which possesses reticulate ornament so that mature specimens of *C. callytharrensis* possess reticulate ornament for about one-third of the curvilinear length of the ventral valve. The spiral ornament of the costae on the ears of "*Dictyoclostus magnus*" is also a result of ontogenetic change; the ears of mature *C. callytharrensis* curl and the incipient costae, mentioned by Prendergast (1943, p. 14) become more strongly developed and appear to spiral or curl around them. The costae in the sulcus also appear to converge into the sulcus only at maturity and hence young specimens of *C. callytharrensis* [as documented by Prendergast (1943) and Coleman (1957)] lack that ornamental feature. As the two species, *D. callytharrensis* and *D. magnus*, have been quoted widely in the literature a full synonymy is given above. Chapman's report (1924a) is retained in the synonymy following Prendergast (1943, p. 13); this would imply that *C. callytharrensis* is present in the Canning Basin (probably the Nura Nura Member) as shown by Coleman (pp. 137-139) but this has not been verified by the present review.

The Western Tibetan, early Artinskian species, *Costiferina sinensis* Sun (1983, p. 125, pl. 16, figs 8-10), a smaller species than *C. callytharrensis*, possesses external ornament similar to that of the Western Australian species. The sulcus of the Tibetan species is narrow and the ears poorly known but *C. sinensis* is provisionally assigned to *Callytharrella*.

Several other large Permian dictyoclostids may be

Fig. 2—A-G, *Callytharrella callytharrensis* (Prendergast). A-G, from Callytharra Formation, Carnarvon Basin. A-D, AMF 36514, gerontic ventral valve in posteroventral, ventral, anterior and lateral views, ×1 (the holotype of *Dictyoclostus magnus* Coleman 1957). E, MUGD F6014, ventral valve in ventral view, ×1. F-G, AMF 36515, ventral valve in posterior and ventral views, ×1.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related to *C. callytharrensis* but comparisons with reports and illustrations are usually hampered by the incomplete nature of the material described or figured. *Productus semireticulatus* of Broili (1916, pl. 2, fig. 14) from Sonnebikoe, Timor of "Bitauni" age approaches *C. callytharrensis* in terms of size but has a less well developed sulcus, smaller ears and finer spines. *Productus spiralis* of Broili (1915, pl. 21, figs 7-9) from a "Bitauni" fauna of Letti is very close to juvenile and submature *C. callytharrensis* in terms of ventral valve outline, dorsal valve geniculation and external ornament. Ontogeny of the Letti species is unknown. *Productus uralicus* Tschernyschew (1902, pl. 32, fig. 1; pl. 33, fig. 1; pl. 62, fig. 1) from the Sakmarian of the Urals is a large species with large ears—without well developed costae—and incipient bundling of the anterior ventral costae, but the finer ornament, particularly that of the dorsal valve recalls *Reticulatia* to which Sarycheva (1977) referred the species. Specimens referred to *Productus uralensis* Licharew by Ustritskiy (1960, pl. 9, figs 3, 4; pl. 10, figs 1-4) from the Sakmarian of the Kun Lun Mountains, China are closer to *C. callytharrensis* in terms of size, ventral sulcus, ornament and ears although costae are not as distinctive on the ventral ears. *Stereochia koyaoensis* Waterhouse (1981) from the Late Sakmarian or Early Artinskian of southern Thailand, is not as large as *C. callytharrensis*, and can be distinguished by means of its coarser costae and smaller ears (Waterhouse 1981, p. 85). *Productus spiralis* Waagen (1884, p. 681; pl. 67, fig. 6; pl. 68, fig. 3) from the Amb Formation of the Salt Range, with which large specimens of *C. callytharrensis* had previously been compared, is a large form that may be allied to *Callytharrella*, but judging from Waagen's illustrations, the ventral reticulate ornament is restricted to about one-fifth of the curvilinear height and the ears are essentially smooth except for a few spines.

Genus Costiferina Muir-Wood & Cooper 1960

Type Species: *Productus indicus* Waagen 1884.

Diagnosis: The diagnosis provided by Muir-Wood and Cooper (1960, p. 277) is accepted.

Discussion: *Costiferina wadei* (Prendergast 1943) is referred herein to *Costiferina* on the basis of its coarse ornament of costae and less extensive reticulate zone. Nevertheless the dorsal interior of the species is poorly known and an absence of a prominent dorsal marginal ridge may permit assignment of the species to *Stereochia* as in Archbold (1982b).

Costiferina wadei (Prendergast 1943)
Fig. 4A-L

1937 *Productus semireticularis*: Wade. *Rep. Aust. N.Z. Assoc. Advmt. Sci.*, 23: 94.

1943 *Dictyoclostus callytharrensis* var. *wadei* Prendergast, p. 16, pl. 1, figs 2-4.

1957 *Dictyoclostus wadei* Prendergast; Coleman, p. 59, pl. 7, figs 7-10.

1958 *Dictyoclostus wadei* Prendergast; Guppy *et al. Bull. Bur. Min. Res. Geol. Geophys.*, 36: 48.

1971 *Costiferina wadei* (Prendergast); Waterhouse. *Proc. Pap. 2nd Gondwana Symp.*, p. 391.

1975 *Dictyoclostus wadei* Prendergast; Playford *et al.*, p. 341.

Holotype: UWA 20453 from ferruginous limestone, 3.2 km east, 10 degrees south of Mount Nicholson, West Kimberley District, from lower half of Noonkanbah Formation.

Material, Localities and Age: Specimens examined by Coleman (1957) and re-examined—see Coleman for localities. In addition, CPC 19912-19914, 2 ventral valves and 1 dorsal valve and several fragments, all from BMR locality KNA 20, about 13 km bearing 120° from Mount Anderson Homestead, west Kimberley Division, about 180 m above base of measured section, south of Grant Range, Noonkanbah Formation, Canning Basin were examined. Late Baigendzinian (Late Artinskian).

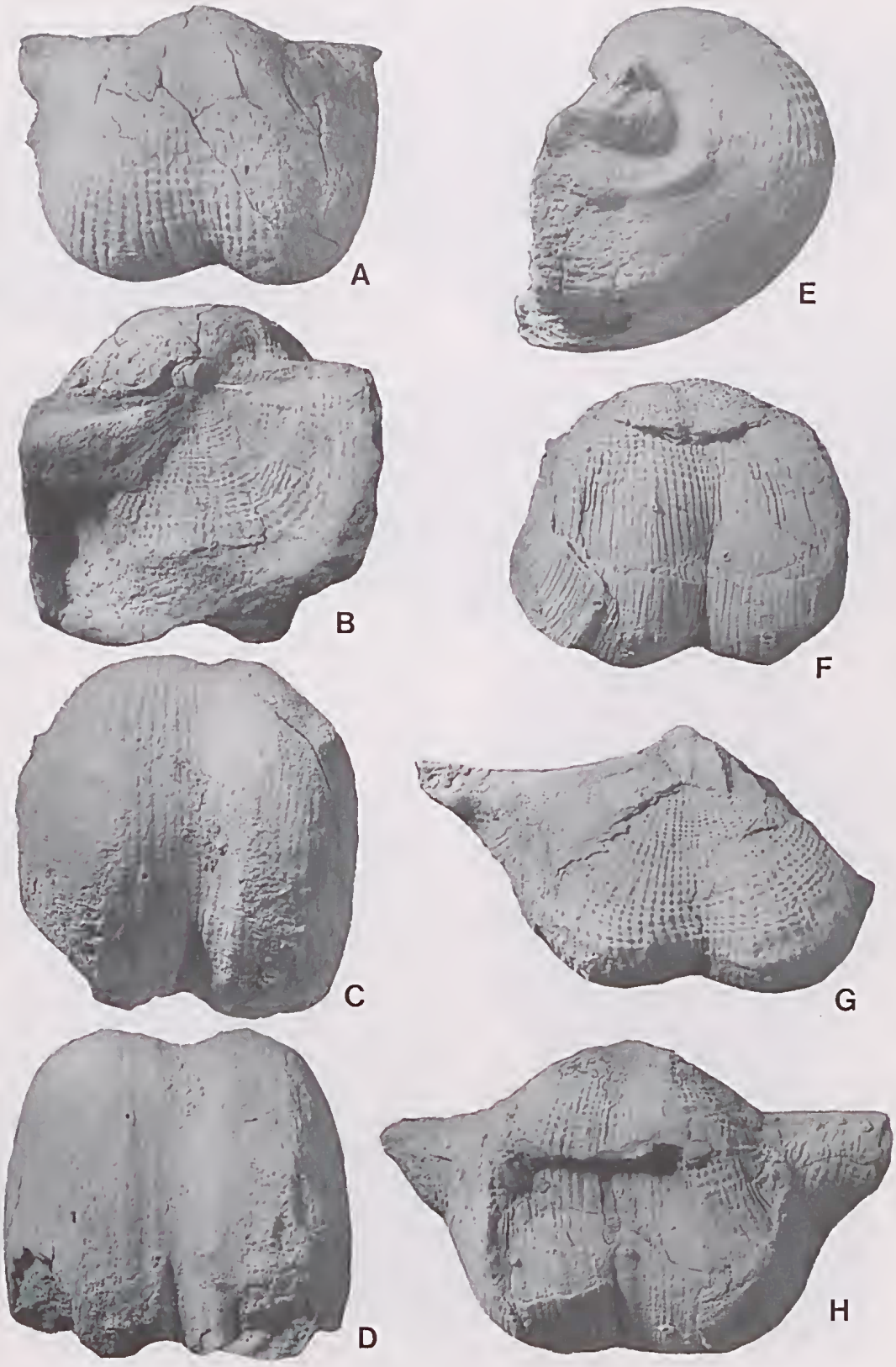
Measurements (in mm):* = holotype c = estimate

Specimen	Hinge width	Midlength width	Ventral height	Dorsal height	Thickness
CPC 19912	60c	46	47	–	31
CPC 19913	46	44	–	–	–
CPC 19914	–	41	–	36+	–
UWA 20453*	63	50	54	–	35
UWA 28696b	37	33	–	22	–

Diagnosis: Average sized for genus with coarse ornamentation. Ears large, quadrate. Costae broad, bifurcating anteriorly of spines. Sulcus distinct, dorsal fold distinct.

Description: Average to large size for genus; outline transverse, widest at hinge at maturity; profile evenly curved; ventral geniculation not pronounced. Ears distinct, quadrate in outline, separated from flanks of ventral valve by low depression at maturity. Anterior margin emarginate producing broad, relatively deep sulcus. Ventral umbo short; visceral disc strongly reticulate, rugae at times particularly strong, sulcus arises within first centimetre of umbo. Costae continue forward of rugae for anterior two-thirds of fully mature shells. Costae strong, coarse (1 to 3 mm wide on trail), crests rounded, occasionally bifurcating—normally on anterior side of spine; costae persist to anterior of trail, converge slightly in sulcus—one or two may be lost. Spines coarse, two large and several smaller spines on ears, two or three coarse spines on flanks close to depression separating ears. Spines scattered at random on trail, about eight functional; diameter of anterior trail spines 2.2 to 3.1 mm on CPC 19912. Dorsal valve visceral disc gently concave, median fold arises within first centimetre of growth. Reticulation strong, especially rugae, no spines but with occasional pits. Hinge edge sharp.

Fig. 3—A-H, *Callytharrella callytharrensis* (Prendergast). A-E, from Jimba Jimba Calcarenite, Carnarvon Basin; F-H, from Callytharra Formation, Carnarvon Basin. A-E, CPC 19911, shell with ears missing in posterior, dorsal, ventral, anterior and lateral views, ×1. F, CPC 19910, ventral valve in ventral view, ×1. G, MUGD F6021, incomplete dorsal valve in ventral view, ×1. H, MUGD F6018, ventral valve in ventral view, ×1.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Ventral interior poorly known except for normally shaped, longitudinally striate, diductor musele scars. Dorsal valve with short, trilobed, robust cardinal process supported by strong lateral ridges.

Discussion: Old reports of collections from the Canning Basin that may indicate this species, under the name *Productus semireticulatus*, are those of Hardman (1885, p. 26) and Chapman (1924b, p. 19; 1925, p. 6). *Costiferina wadei* is now well known except for details of the dorsal interior. Coleman (1957, p. 59) noted that the dorsal interior features of *C. wadei* are similar to those of *Callytharrella callytharrensis* except that "the dendritic adductor musele impressions are set closer to the hinge-line". The available information on the morphology of the species strongly supports its assignment to *Costiferina*. Although *C. wadei* was compared with *Stereochia* by Grant (1976) and Archbold (1982b), the coarse ventral costae strongly recall those of *Costiferina* and hence permit a more restricted diagnosis for *Stereochia* with only *S. litostyla* Grant (1976) and *S. irianensis* Archbold (1982b) being reliably attributed to that genus.

Typical species of *Costiferina* with coarse ventral costae such as *C. indica* Waagen and *C. vishnu* Waagen as figured by Muir-Wood and Cooper (1960, pl. 95, figs 6-7; pl. 103, figs 1-12) differ from *C. wadei* in possessing somewhat shallower sulci and *C. vishnu* possesses much weaker dorsal reticulate ornament and reduced ventral ornament anteriorly. *Costiferina indica* Waagen (1884, pl. 70, figs 1-6) from a variety of horizons in the Middle and Upper Productus Limestones of the Salt Range is closest to *C. wadei* but differs in its generally smaller size and normally less prominent ears. *Costiferina alata* Waterhouse (1966) is a much larger species with alate ears and comes from Chhidruan strata of Nepal (see also Waterhouse 1978a, pl. 2, figs 21, 22; pl. 3, figs 1-5) Kashmir (Waterhouse & Gupta 1979, pl. 4, figs 1-3) and Tibet (Chang & Ching 1976, pl. 6, figs 1-10). Specimens from the Chhidruan of Tibet illustrated by Ting (1962, pl. 3, fig 3a-d) and attributed to Waterhouse's species by Chang and Ching (1976) possess broad dorsal costae that dominate the dorsal reticulate ornament much as in the dorsal ornament of *C. wadei*. *Costiferina miaolingensis* Lee and Gu (1980, in Lee *et al.* 1980) from the Late Early Permian of Inner Mongolia is also a transverse form with wide ears and costae finer than those of *C. wadei*.

Although referred to *Tyloplecta* by Muir-Wood and Cooper (1960), *Productus sumatrensis* Roemer (1880, pl. 1, fig 4a-b; specimen refigured more accurately by Fliegel 1901, pl. 6, figs 1a-e) from the Kungurian of Sumatra appears to be a *Costiferina* and is close to *C. wadei* in details of size and ventral sulcus but the costae of *C? sumatrensis* do not appear to converge in the sulcus. The dorsal valve reticulate ornament of *C? sumatrensis* (see Meyer, 1922, pl. 2, fig. 5a) is similar to that of *C. wadei*.

Costiferina thomasi sp. nov.
Fig. 5A-K

1957 *Dictyoclostus* sp. Thomas, p. 181.
1958 *Dictyoclostus* sp. Thomas, *Abstracts ANZAAS 1958, Sec. C*, p. 3
1969 *Costiferina* sp. nov. Thomas, p. 221

Etymology: For Dr G. A. Thomas, collector of the species.

Holotype: CPC 24332, an external mould of a dorsal valve from the Upper Marine Beds, Port Keats Group, Bonaparte Gulf Basin.

Material, Localities and Age: CPC 24332-24334, one dorsal valve external mould (holotype), one incomplete dorsal valve external mould and one incomplete dorsal valve internal mould, all from G. A. Thomas locality PK4, on coast approximately 13.5 km north of Cape Dombey, Port Keats Area, Northern Territory, Upper Marine Beds, Port Keats Group. CPC 24335-24337, one internal mould of a ventral valve, one incomplete external mould of a dorsal valve and one natural cast of a fragment of a dorsal valve, all from G. A. Thomas locality PK1, Tchindi Beach, approximately 15 km west of Port Keats Mission, Northern Territory, Upper Marine Beds, Port Keats Group, Bonaparte Gulf Basin (see Thomas 1957, p. 176 for map of localities). Chhidruan.

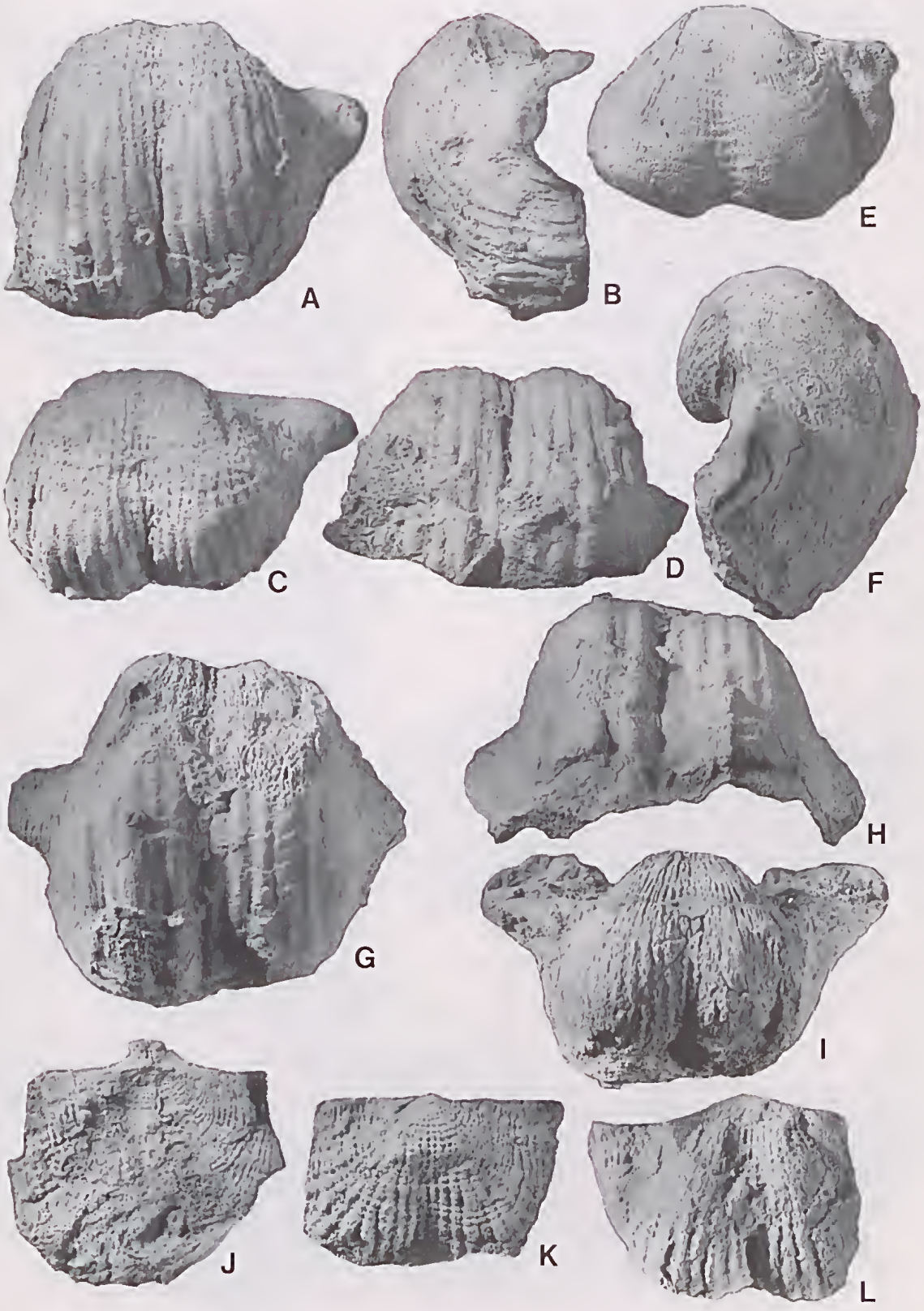
Measurements (in mm):* = holotype, e = estimate

Specimen number	Hinge width	Midlength width	Ventral height	Dorsal height
CPC 24332*	58	47e	–	39
CPC 24333	82e	66e	–	43
CPC 24334	–	66+	–	46
CPC 24335	68	61	54	–
CPC 24336	72e	60e	–	45e
CPC 24337	–	–	–	38

Diagnosis: Moderately large for genus. Well developed reticulate ornament on dorsal visceral disc. Costae on trail relatively fine for genus. Dorsal fold well developed on trail. Ears prominent on mature specimens.

Description: Moderately large for genus; outline transverse, widest at hinge at maturity. Ventral geniculation distinct, dorsal geniculation sharp, turning through 90°. Ears subquadrate at submaturity, distinctly alate in mature specimens. Anterior margin emarginate producing relatively broad, shallow sulcus. Ventral umbo low. Ventral exterior ornament poorly known. Anterior of ventral valve preserved on CPC 24336 reveals strong costae varying from 2.0 to 2.8 mm wide with rounded crests. Spines distinct on trail but few in number, scattered randomly; spine bases about 2 mm in diameter.

Fig. 4—A-L, *Costiferina wadei* (Prendergast). A-L, from Noonkanbah Formation, Canning Basin. A-D, CPC 19912, ventral valve in ventral, lateral, posterior and anterior views, ×1. E, CPC 19913, worn ventral valve in ventral view, ×1. F-I, holotype, UWA 20453, ventral valve in lateral, ventral, anterior and posterior views, ×1. J, CPC 19914, dorsal valve in dorsal view, ×1. K, UWA 28696b, external mould of dorsal valve, ×1. L, UWA 28696a, incomplete ventral valve in ventral view, ×1.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Ventral sulcus only weakly developed on trail. Dorsal valve with gently concave visceral disc with low median fold arising within 2 cm of umbo. Fold more pronounced on trail of dorsal valve. Reticulate ornament extends over entire visceral disc with costae becoming dominant at anterior of disc and rugae being absent on trail. Size of visceral disc varies greatly between individuals indicating considerable size variation within species. Trail strongly costate, costae ranging from 1.5 to 3.0 mm wide. No dorsal spines but abundant low, elongate shallow pits scattered over visceral disc—probably reflecting the ventral spine positions. Hinge edge sharp. Ventral interior moderately deep with large diductor scars, longitudinally striated. Exterior ornament not reflected on interior of ventral visceral disc. Dorsal interior with broad marginal ridge across ears, apparently continuing anteriorly around visceral disc; cardinal process large, trilobed with prominent median lobe. Process supported by lateral ridges and median septum which continues forward between muscle scars, terminating about two-thirds distance to geniculation. Adductor scars in two pairs, median pair extending forward further than lateral pair; brachial ridges relatively weak, tear-shaped anteriorly. Dorsal exterior reticulate ornament reflected weakly on anterior of visceral disc.

Discussion: *Costiferina thomasi* sp. nov. remains imperfectly known in terms of ventral exterior and full details of the dorsal interior. It appears to be a variable species and large collections are required to assess this. However the material is distinctive and hence is formally named.

Costiferina wadei is distinguished from the new species by its coarser ventral spines and coarser costae on its trail. Dorsal valve costae towards the anterior of the visceral disc on *C. wadei* are also much coarser than those of *C. thomasi*. *Costiferina alata* Waterhouse (1966) approaches *C. thomasi* sp. nov. with its alate ears in mature individuals but is a larger species and possesses much coarser costae over the dorsal visceral disc. The dorsal exterior figured by Waterhouse (1978, pl. 2, fig. 21) from the Chhidruan of Nepal approaches that of *C. thomasi* sp. nov. and indicates that *C. alata* can possess finer dorsal ornament. Of Waagen's (1884) species attributed to *Costiferina*, *C. indica* possesses much coarser costae on the ventral trail and is a smaller species with less alate ears. *C. vishnu* possesses weakly developed dorsal reticulate ornament and anterior ventral costae.

The Basleo specimens referred to *Productus spiralis* by Broili (1916, pl. 3, figs 3, 4) appear to be close to *C. thomasi* sp. nov. because their costae are relatively fine for *Costiferina* and the zone of reticulate ornament is moderately extensive. *Costiferina* spp. figured by Shimizu (1981, pl. 7, figs 15-19) from various late Permian units of Kashmir, although poorly known, are noteworthy because of their extensive dorsal reticulate ornament, hence recalling *C. thomasi* sp. nov.

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Dr G. A. Thomas read an earlier version of the manuscript and Mrs I. Munro typed the manuscript.

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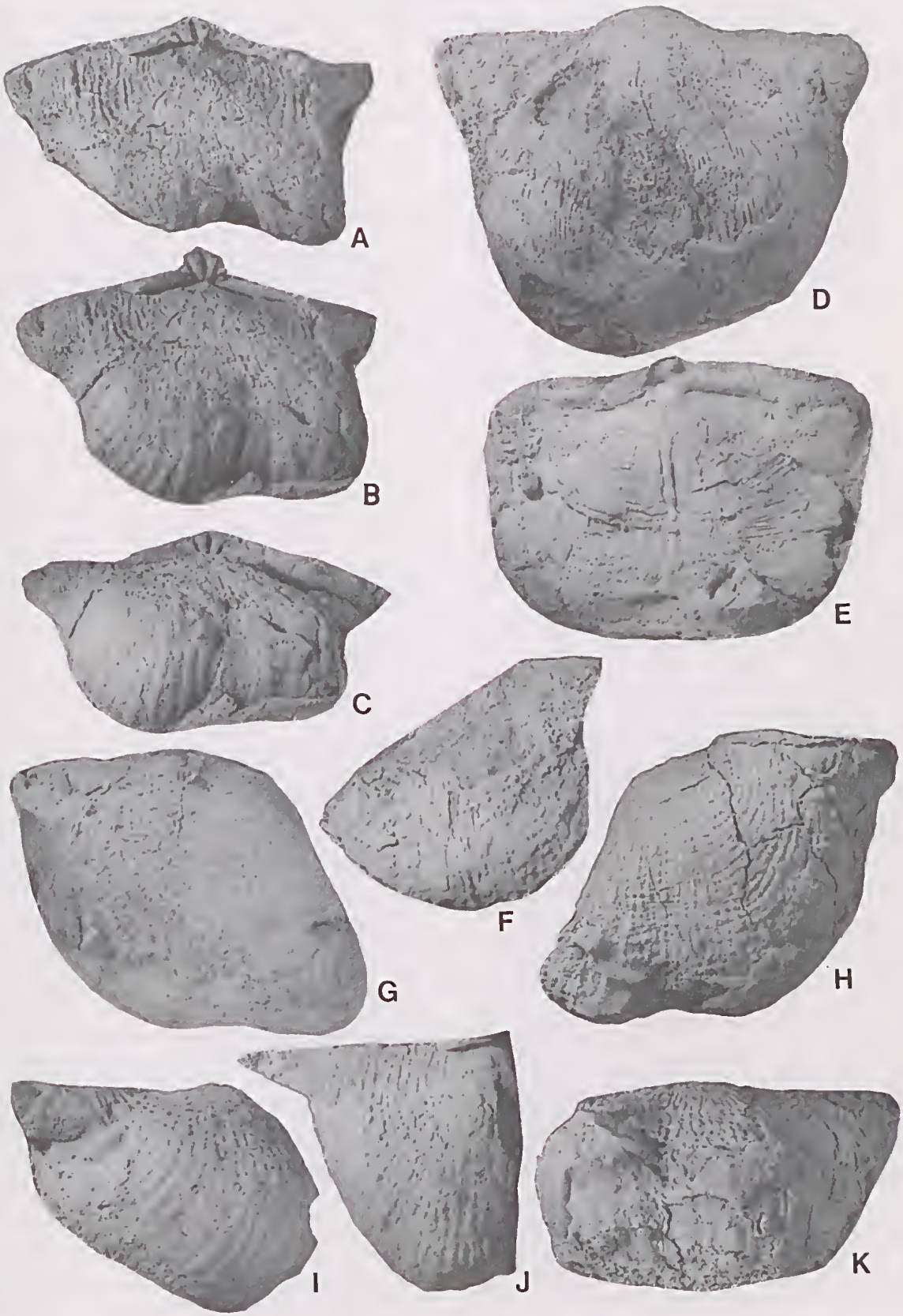
Fig. 5—A-K, *Costiferina thomasi* sp. nov. A-K, from Upper Marine Beds, Port Keats Group, Bonaparte Gulf Basin. A-C, holotype, CPC 24332, dorsal valve external mould in three views, progressively tilted, ×1. D, CPC 24335, ventral valve internal mould in ventral view, ×1. E, CPC 24334, latex replica of dorsal valve internal mould, ×1. F, CPC 24337, natural cast of fragment of dorsal valve interior, ×1. G,H,K, CPC 24336, latex replica of dorsal valve external mould and dorsal valve external mould in direct and anterior views, ×1. I,J, CPC 24333, incomplete dorsal valve external mould in lateral and direct views, ×1.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